ORIGINAL ARTICLE

DRAWING THE DIGITAL DESIGN OF DENTAL BRIDGES IN CLINICAL SITUATIONS WITH MODIFIED POTENTIAL PROSTHETIC SPACE

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Abstract: *Background*: The first digital revolution took place many years ago, with the production of dental restorations such as veneers, inlays, crowns and bridges using CAD/CAM systems. The reduction in the cost of processing power will ensure these developments continue, as exemplified by the recent introduction of a new range of digital intraoral scanners. The aim of this study was to evaluate the application of the digital design of dental bridges in clinical situations with potentially modified prosthetic space, with the help of EXOCAD software. *Methods*: For this study, there were analyzed existing data regarding the possible use of digital designs in potential maxillary and mandibular, frontal and lateral potential spaces in a private dental office between March 2024 and March 2025. *Results*: 24 patients were analyzed and the presence of 2 major groups of changes in the potential prosthetic space in the vertical plane was confirmed, divided into increased potential prosthetic space and decreased potential prosthetic space, but also the presence of some patients who did not show changes in the vertical plane. *Conclusions*: Thanks to CAD/CAM technology and EXOCAD software, communication between the dentist and the dental technician is more efficient and faster.

Keywords: digital design, EXOCAD, dental bridge, CAD/CAM technology

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1. Introduction

The first digital revolution took place many years ago, with the production of dental restorations such as veneers, inlays, crowns and bridges using CAD/CAM systems. The reduction in the cost of processing power will ensure these developments continue, as exemplified by the recent introduction of a new range of digital intraoral scanners.

In terms of prosthetic manufacturing, it is currently dominated by subtractive processing technology, but it is inevitable that additive processing routes of layered manufacturing, such as FDM, SLA, SLM and inkjet printing, will begin to have an impact.

There is no reason why the technology cannot be extended to all aspects of denture manufacturing and include custom implants, full denture construction and orthodontic appliances. In fact, anything you might expect a dental lab to produce can be done digitally, and potentially more consistently, faster, and at a lower cost.

The manufacturing of dental devices will experience a second revolution when layered manufacturing techniques will reach the point of being able to produce high-quality dental prostheses. The challenge for the dental materials research community is to combine technology with materials that are suitable for use in dentistry. This may take dental materials research in a totally different direction [1].

The aim of this study was to evaluate the design of the digital design of dental bridges in clinical situations with potentially modified prosthetic space, with the help of EXOCAD software. EXOCAD is a program that allows the creation of prosthetic parts that meet the requirements of the dentist, but also the patient, being excellent from the point of view of reducing the time needed to create a restoration and the communication between the doctor and the dental technician [2].

2. Materials and method

Clinical-statistical study

For this study, we analyzed existing data regarding the possible use of digital designs in potential maxillary and mandibular, frontal and lateral potential spaces within SC Centrul Medical OM during the period March 1, 2024 – March 1, 2025. According to a protocol approved by the Ethics Committee of the University of Medicine and Pharmacy of Craiova (no. 83/ 19.02.2024).

For this purpose, data were taken from the consultation register as well as from the MeditLink software (Medit, Seoul, South Korea), used for intra-oral scanning, and the following parameters were noted: name, gender, age, missing teeth, change in vertical potential prosthetic space, change in horizontal potential prosthetic space, size of potential prosthetic space.

The data obtained were entered into an Excel table and analyzed statistically, and the results obtained were presented in the form of tables and graphs.

Representative cases

In order to document the digital designs, 4 representative cases were selected for which, after obtaining the patient's informed consent and agreement, the clinical stages of intraoral digital impression were performed using the Medit i700 scanner (Medit, Seoul, South Korea) and the obtained data were transferred to the EXOCAD digital design software (Exocad GmbH Darmstadt Germany).

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Within the dental technique laboratory of the University of Medicine and Pharmacy, Craiova, we designed the dental bridges designs in these clinical situations with potentially modified prosthetic space and screenshots were taken to highlight the stages of the digital techniques for creating the digital design, simulating several reconstruction possibilities depending on the particularities of the clinical case.

3. Results

3.1 Clinical and statistical study results

The study included the examination of 24 patients, 13 of whom were females and 11 males (Figure 1).

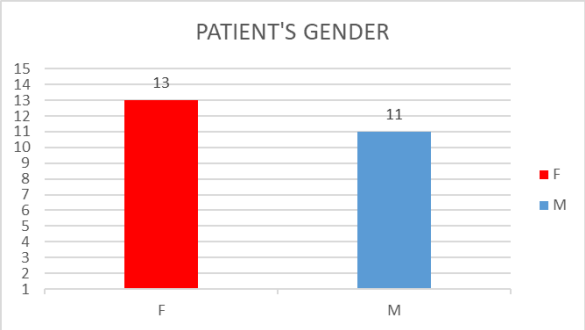

Figure 1. Distribution of cases analyzed by gender.

Among the 24 cases, 6 age groups were found, from 30 years old to over 80. The predominant age group was 50-60 years old, representing 38% of the total patients, and the group with the fewest integrated patients was 80+, representing 4% of the total (Figure 2).

Regarding the potential prosthetic present spaces, we divided the missing teeth into 4 quadrants. The most predominant hemiarches with missing teeth are quadrants 2 and 4, each with 17 missing teeth, and the least affected quadrant is the first, with a value of 5 (Figure 3).

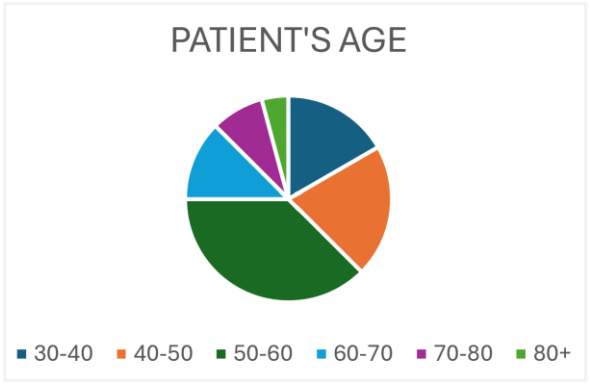

Figure 2. Distribution of cases analyzed by age.

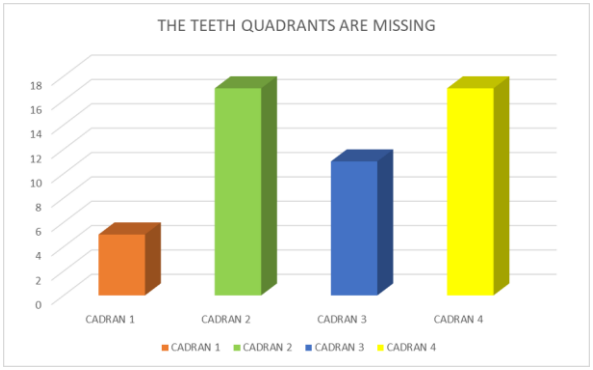

Figure 3. Distribution of cases analyzed by age.

The 24 patients were analyzed and the presence of 2 major groups of changes in the potential prosthetic space in the vertical plane was confirmed, divided into increased potential prosthetic space and decreased potential prosthetic space, but also the presence of some patients who did not show changes in the vertical plane. In the table presented, we observe a number of 9 patients with decreased potential prosthetic space, most of them falling into small decreased potential prosthetic space and only 2 into medium decreased potential prosthetic space. In contrast, the distribution of patients presenting an increased potential prosthetic space is more balanced, 3 of the patients presenting a small increased potential prosthetic space and 4 a medium increased potential prosthetic space (Figure 4).

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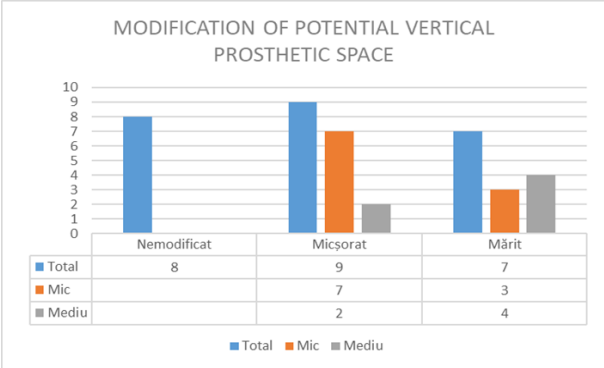
In the diagram below we have the representation of patients according to changes in the potential prosthetic space in the horizontal plane (Figure 5). While 10 patients out of the total number of 24 did not present changes in the horizontal plane, the remaining 14 fell into either the reduced horizontal prosthetic potential space category or the increased horizontal prosthetic potential space category.



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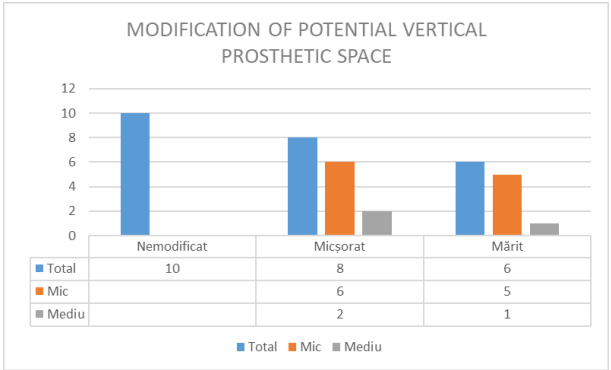

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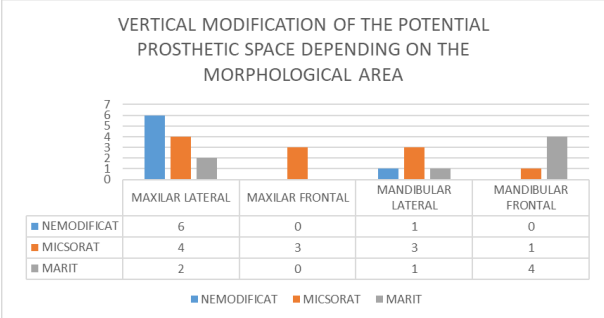

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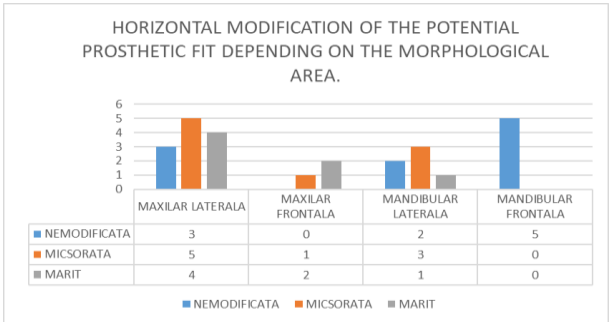

(Figure 7)

Figure 4. Distribution of the size of the potential prosthetic space in the vertical plane. **Figure 5.** Distribution of the size of the potential prosthetic space in the horizontal plane. **Figure 6.** Distribution of changes in the potential prosthetic space in the vertical plane, depending on the morphological area. **Figure 7.** Distribution of changes in the potential prosthetic space in the horizontal plane, depending on the morphological area.

In Figure 6, we divided the changes in the potential prosthetic space in the vertical plane, depending on the morphological area. Predominantly, changes in the potential prosthetic space were noted in the lateral maxillary area and in the frontal mandibular area.

Figure 7 highlights the distribution of changes in the potential prosthetic space in the horizontal plane, correlated with the topography of the edentulous region, classified into the four morphological zones: lateral maxilla, frontal maxilla, lateral mandibular and frontal mandibular.

First case

For the first case, with the help of the EXOCAD program, we made the design of a temporary dental bridge made immediately post-extraction in the maxillary frontal area, which will replace the absent tooth 2.1 and will rest on teeth 1.3, 1.2, 1.1, 2.2 and 2.3 which were used as abutment teeth. The prosthetic particularity of this case was

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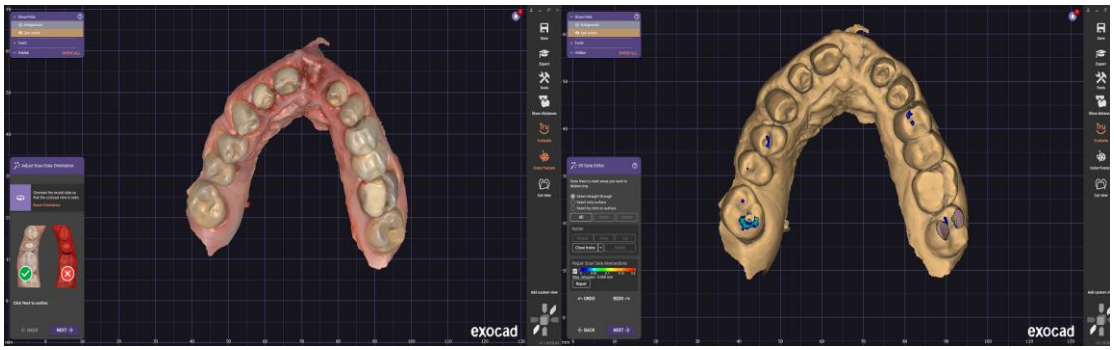
represented by the increase of the potential prosthetic space as a result of the periodontal diseases that determined the excessive vestibularization of the upper left central incisor and finally required its extraction. To solve this situation, it was initially decided to make a central incisor within the body of the bridge, where a modeling of the coronal third of the root was also made, partially simulating the existing situation before its extraction, but keeping a space for post-extraction sanitation. Another design option that was simulated was the creation of an ovoid bridge body to esthetically direct post-extraction healing.



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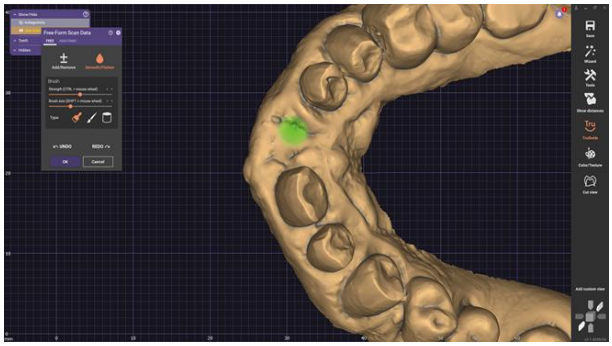

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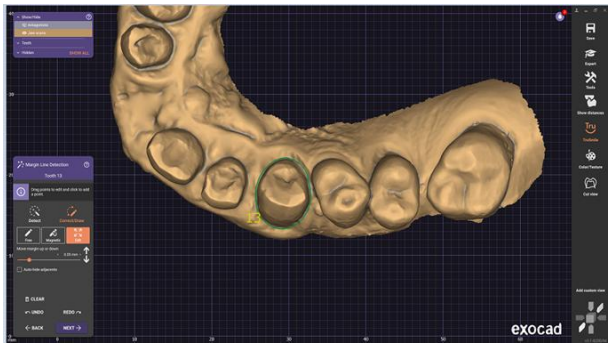

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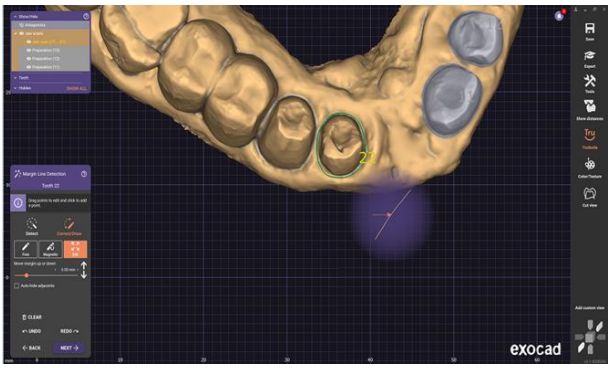

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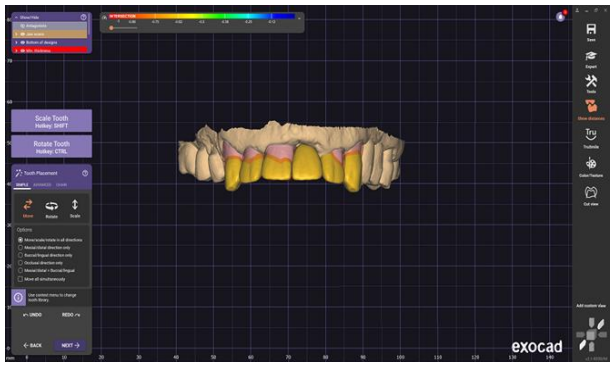

(Figure 1.5)

Figure 1.1. Digital impression made immediately post-extraction. **Figure 1.2.** Partial leveling of the post-extraction alveolus, using the function ,,smooth/flatten. **Figure 1.3.** Drawing the margin line at the level of the tooth 1.3. **Figure 1.4.** Drawing the margin line at. the level of the tooth 2.2. Figure 1.5. The initial tooth model suggestion from the software library. **Figure1.5.** The initial tooth model suggestion from the software library.

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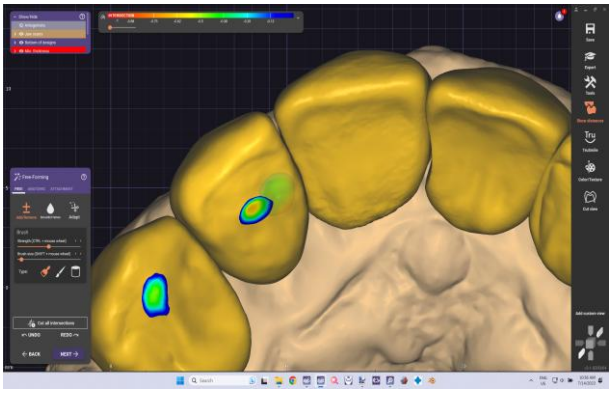

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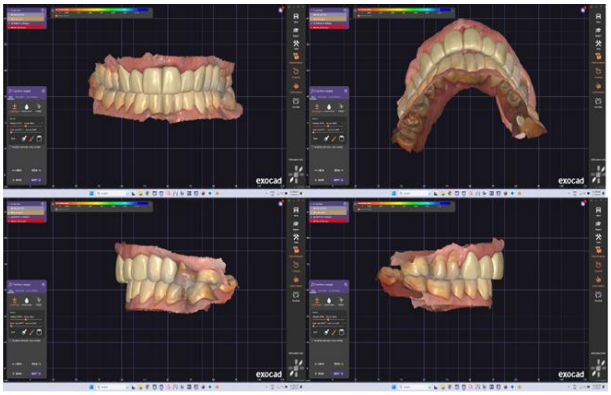

(Figure 1.7)

Figure 1.6. Highlighting the contact areas obtained at the level of teeth 1.3 and 1.2 and the intensity of occlusal contacts. **Figure 1.7**. The final design of the prosthetic restoration.

Second case

In the second case, also with the help of the EXOCAD program, we made the design of a temporary dental bridge made immediately post-extraction in the frontal mandibular area, which will replace the absent teeth 3.1 and 4.1 and will rest on the teeth 3.3, 3.2 and 4.2, 4.3 which were used as abutment teeth. The prosthetic particularity of this case was represented by the vertical growth of the potential prosthetic space through the atrophy of the edentulous ridge as a result of the periodontal diseases that required the extraction of the central incisors. To solve this situation, it was initially decided to make the missing central incisors with a modeling of the coronal third of the root was also made, partially simulating the existing situation before their extraction, but keeping a space for post-extraction hygiene. Another design option that was simulated was the creation of an ovoid bridge body to esthetically direct post-extraction healing.

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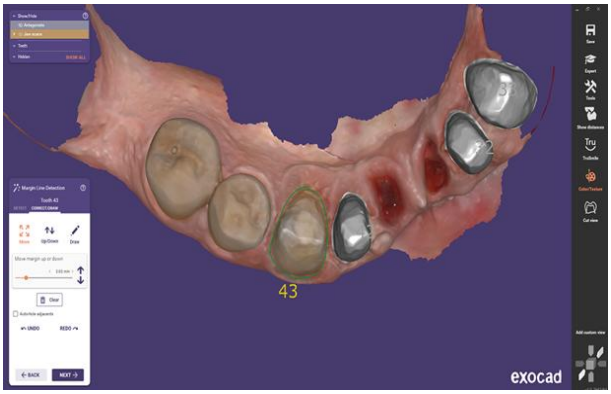

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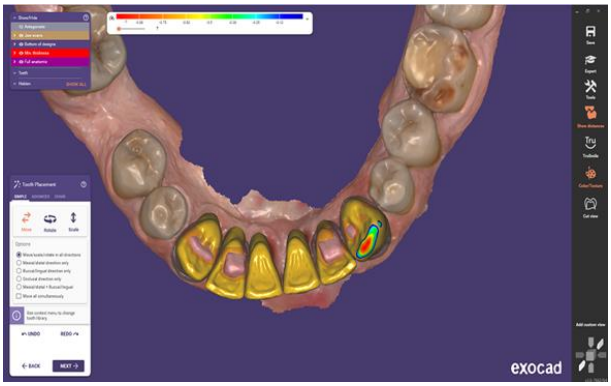

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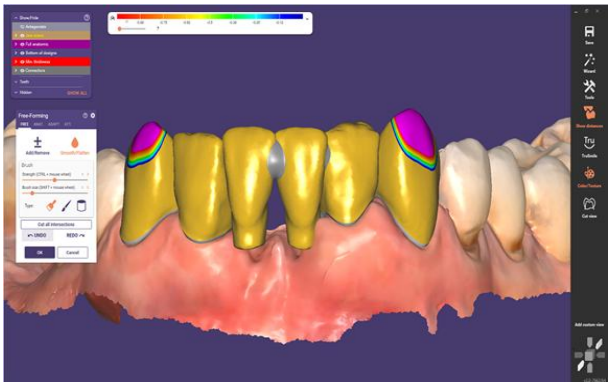

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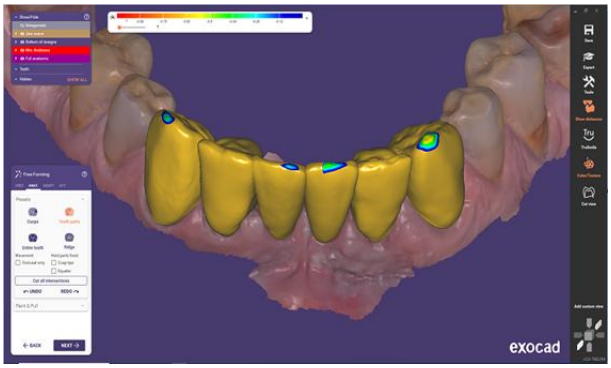

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Figure 2.1. Overview of the initial situation of the mandibular arch after the preparation. **Figure 2.2.** Drawing the margin line at the level of the tooth 4.3. **Figure 2.3.** Drawing the margin line at the level of the tooth 4.2. **Figure 2.4.** Drawing the parcel line at the level of the tooth 3.3. **Figure 2.5.** Initial tooth shape selection made by EXOCAD software from its library. **Figure 2.6.** Highlighting the areas of occlusal contact with the opposing arch and the initial shape of the interdental connectors. **Figure 2.7.** Final appearance of the provisional bridge design.

Third case

In the third situation we made the design of a dental bridge in the left mandibular lateral area, which will replace the missing teeth 3.6 and 3.7 and will rest on the teeth 3.5 and 3.8 which were used as abutment teeth. The prosthetic particularity of this case was represented by the horizontal reduction of the potential prosthetic space by the tipping migration of the teeth neighboring the

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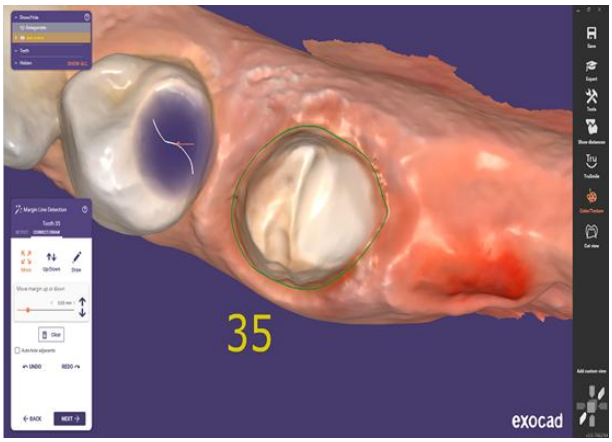
edentulous gap, especially the wisdom molar. To solve this situation, it was decided to create a second molar of small dimensions within the body of the bridge.



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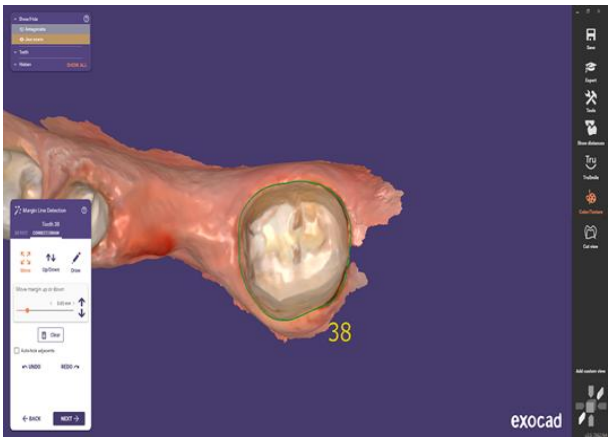

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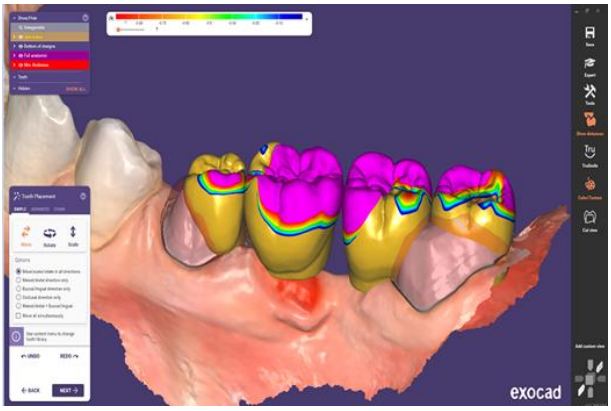

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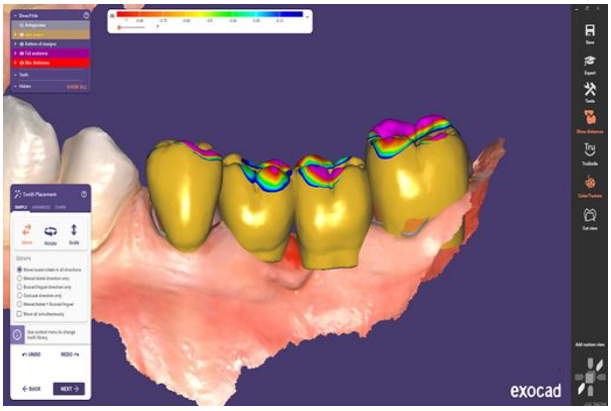

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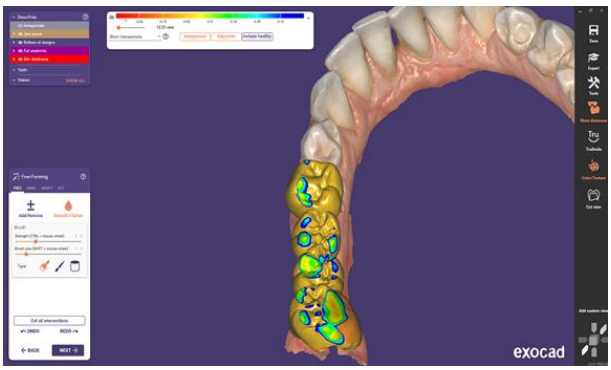

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Figure 3.1. Drawing the margin line at the level of the tooth 3.5. **Figure 3.2.** Drawing the margin line at the level of the tooth 3.8. **Figure 3.3.** The initial choice of the tooth shape of the future restoration, made by EXOCAD from the existing tooth library. **Figure 3.4.** Changes to the initial placement made from the teeth placement menu. **Figure 3.5.** Manual adaptation of occlusal relationships, final result.

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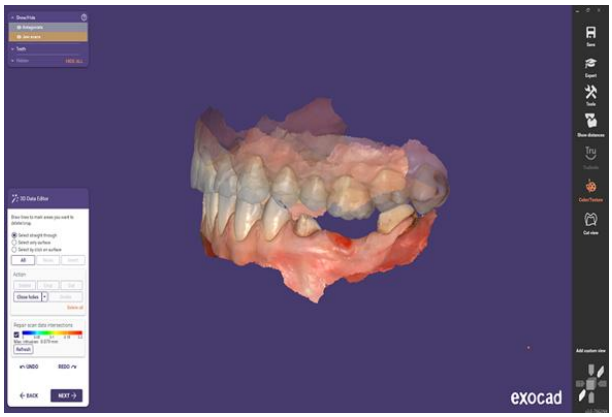
The fourth case

For the last case, with the help of the EXOCAD program we made the design of a dental bridge in the left mandibular lateral area, which will replace the absent tooth 3.6 and rest on teeth 3.5 and 3.7 which were used as abutment teeth. The prosthetic particularity of this case was represented by the vertical reduction of the potential prosthetic space by the extrusion of the opposing molar to the edentulous space.



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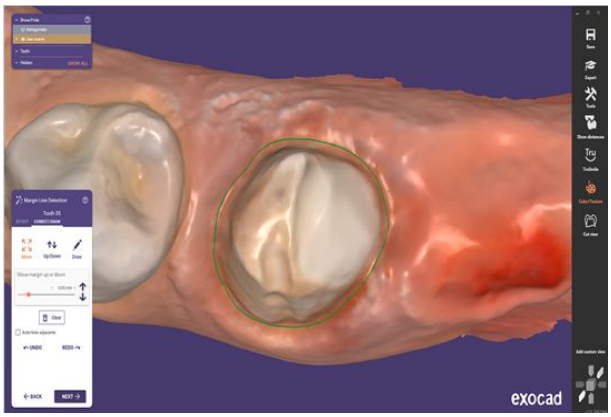

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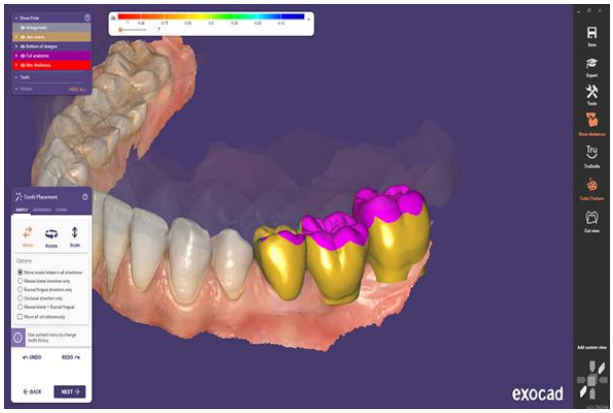

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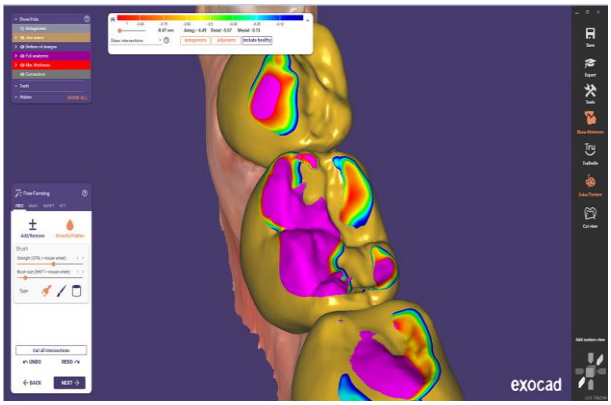

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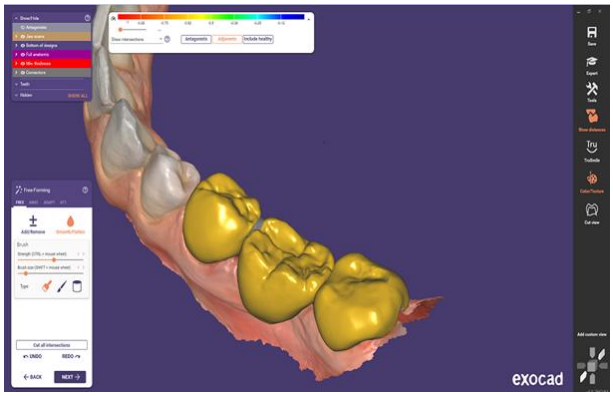

(Figure 4.5)

Figure 4.1. The initial appearance.

Figure 4.2. Drawing the margin line 3.5.

Figure 4.3. Initial choice of tooth shape made by EXOCAD software in its library.

Figure 4.4. Highlighting the occlusal contact areas.

Figure 4.5. The final design of the prosthetic restoration.

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4. Discussion

The knowledge about the muscles and the size of the face contributes to the design of a perfect aesthetic smile. Since not all individuals are the same, each person should study their facial anatomy and find their perfect smile. Although in practice a software is used to predict a perfect smile, a multidisciplinary approach that includes several branches of dentistry is needed [3].

Intraoral scanners as well as software programs have developed in recent years, and this has led to good communication between the doctor and the dental technician.

In recent years, several intraoral scanners have appeared on the profile market, but the best criterion for choice must be the accuracy of the data extracted from the scan [4]. Especially in the case of children, the method using an intraoral scanner is clinically accepted as an easier and more comfortable method. In the patient's perception, the comfort provided by intraoral scans compared to the classic method using alginate, as well as the sensation of pain or vomiting, or dry mouth is well known [5].

Digital scanning offers benefits such as obtaining the perfect impression, with maximum precision every time, possibility of virtual simulation of treatments, better contact between patient and dentist [6].

Digital methods for detecting and drawing the margin lines of dental preparations reduce manual operations, but the accuracy of correctly detecting the placement of the cervical edge may differ, depending on the clinical situation, because the automatic detection depends on the software that analyzes the particularities of the images [7].

Dental materials and 3D restorations have grown significantly in recent years. The progress of digital dentistry is enormous and consists in the appearance of CAD/CAM imaging and milling systems [8,9]. 3D printing is the most revolutionary field in digital dentistry.

The CAD process for fixed prostheses requires drawing a cervical line on the prepared tooth. The first step in the design project is the execution of the finish line, which must match the marginal adaptation of the future prosthesis [10].

The success of a crown manufactured using the CAD-CAM technique is determined by several factors such as aesthetic appearance, strength and marginal adaptation.[11] Marginal and internal fit is significant in ensuring the success of crowns and can be negatively influenced by cement layer thickness, marginal fit, pressure force, type of material and CAD-CAM system used.

Through the digital workflow, personalized abutments and personalized crowns are made and thus the maintenance of soft tissues is made easier, and an advantage is the use of a high-performance restorative material [12].

In patients with a single implant, monolithic restorations had high success rates, without severe complications in a relatively short period of time 3-5. Patient acceptance and low clinical and laboratory time were high [13].

The accuracy of a impression depends on the data matching algorithm. Intraoral scanners lack a fixed reference; therefore, the first scanned image is used as a reference, and all subsequent images are stitched onto the previous image using an image matching

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algorithm. A larger area in size requires more merging processes which can lead to results with more considerable errors [14,15].

The virtual articulator improves denture design by adding visual analysis to the design process performed by CAD systems. It provides flexibility in tailoring the treatment plan to the unique needs of the patient. With some classic articulators, some positions cannot be adjusted, but this obstacle can be easily overcome. Thus, the prostheses produced with the help of the virtual articulator are more precise than those where a classic articulator was used. Virtual models that are digitally mounted in the virtual articulator are used for diagnosis and planning of prosthetic treatments, from single or multiple crowns to dental bridges, including complex cases such as full mouth rehabilitation [16]. Arakida et al. reported the importance of ambient light during intraoral scanning; The values of 3900 K and 500 lux of ambient light are a mandatory condition, a normal thing for clinc ambient. Under these conditions, the scan is more faithful and the scan time can be changed compared to other ambient light conditions [17].

It was shown that the surface coating process did not cause large differences and it was concluded that the coating and non-coating procedures did not influence the accuracy of the scanning systems. The accuracy of an intraoral scan can be affected by the operator's experience using intraoral scanners. Experience is a necessary condition in daily clinical practice [18,19].

5. Conclusions

CAD/CAM technology is increasingly used in dental practices. Thanks to advances in CAD/CAM technology, the dentist can make a temporary work for the patient right in the dental office. Using the EXOCAD software, the treatment plan can be customized to meet the individual wishes and needs of each patient. Zirconia is frequently used as a material for making dental bridges because it offers increased resistance, very good aesthetics, but also long-term stability.

Thanks to CAD/CAM technology and EXOCAD software, communication between the dentist and the dental technician is more efficient and faster.

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The authors declare no conflicts of interest concerning this study.

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Will be provided on request.

Ethics statement

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